WHAT IS CLAIMED IS:

1. A method for controlling the level of exhaust gas recirculation (EGR) admitted into a combustion chamber of a reciprocating engine comprising the steps of:

evaluating an ionization signal;

adjusting the level of EGR admitted into the combustion chamber based on the evaluation of the ionization signal.

2. The method of claim 1 wherein the step of adjusting the level of EGR admitted into the combustion chamber comprises the steps of:

comparing a real time average ion current signal to a target ion current wave form corresponding to a desired level of EGR; and

adjusting the level of EGR admitted into the combustion chamber such that the real time average ion current signal is within a tolerance window of the target ion current wave form.

3. The method of claim 2 wherein the step of adjusting the level of EGR admitted into the combustion chamber further includes adjusting the level of EGR admitted into the combustion chamber to a highest level such that the average real time ion current signal is at a minimum level where misfire does not occur.

4. The method of claim 3 wherein the step of adjusting the level of EGR to the highest level such that the average real time ion current signal is at the minimum level where misfire does not occur comprises the steps of:

increasing the level of EGR until an individual cycle ionization signal curve has an area at or below a threshold level;

defining a target level for the running average at the point that is one cycle before the individual cycle ionization signal curve with an area at or below the threshold level; and

lowering the level of EGR to the a level such that the average ionization curve for that engine condition stays proximate to the target level.

5. The method of claim 2 further comprising the steps of:

lowering the target average ion current to increase the desired level of EGR; and

raising the target average ion current to decrease the desired level of EGR.

6. The method of claim 5 further comprising the step of determining a starting point of the average ionization current above a threshold level corresponding to the desired

level of EGR and wherein the step of comparing an average ion current signal to the target average ion current comprises the step of comparing a starting point of the average ionization current to a desired starting point target for the rise of the average ionization current.

7. The method of claim 1 further comprising the step of measuring the ionization signal with a negative polarity of ionization on the electrode of an ion sensor.

8. The method of claim 2 further comprising the steps of:

receiving a plurality of ion current signals over a plurality of engine combustion cycles; and

averaging the plurality of ion current signals to derive the real time average ion current.

9. The method of claim 8 wherein the step of receiving the plurality of ion current signals over a plurality of engine combustion cycles comprises the step of measuring the plurality of ion current signals over a set number of engine combustion cycles.

10. The method of claim 9 wherein the step of measuring the plurality of ion current signals comprises the step of measuring the plurality of ion current signals using a spark plug type of ion sensor.

11. The method of claim 9 wherein the step of measuring the plurality of ion current signals comprises the step of measuring the plurality of ion current signals using an ion sensing apparatus integral with an ignition system.

12. The method of claim 1 wherein the ionization signal has a second peak corresponding to the peak temperature of the combustion process and the step of adjusting the level of EGR admitted into the combustion chamber based on the evaluation of the ionization signal comprises the steps of:

comparing a real time average of a crank shaft angle of the second peak of the ionization signal to a target angle of the second peak of the ionization signal corresponding to a desired level of EGR; and

adjusting the level of EGR admitted into the combustion chamber such that the real time average of the angle of the second peak of the ionization signal is within a tolerance window of the target angle.

13. The method of claim 12 wherein the step of adjusting the level of EGR admitted into the combustion chamber such that the real time average of the angle of the second peak of the ionization signal is within a tolerance window of the target angle comprises the steps of:

if the real time average of the crank shaft angle of the second peak of the ionization signal is advanced of the target angle, increasing the level of EGR until the real time average of the crank shaft angle of the second peak of the ionization signal is within a tolerance of the target angle; and

if the real time average of the crank shaft angle of the second peak of the ionization signal is retarded of the target angle, decreasing the level of EGR until the real time average of the crank shaft angle of the second peak of the ionization signal is within a tolerance of the target angle.

14. A method for controlling the level of exhaust gas recirculation (EGR) admitted into a combustion chamber of a reciprocating diesel engine comprising the steps of:

evaluating an ionization signal;

adjusting the level of EGR admitted into the combustion chamber based on the evaluation of the ionization signal.

15. The method of claim 14 wherein the step of adjusting the level of EGR admitted into the combustion chamber comprises the steps of:

comparing a real time average ion current signal to a target ion current wave form corresponding to a desired level of EGR; and

adjusting the level of EGR admitted into the combustion chamber such that the real time average ion current signal is within a tolerance window of the target ion current wave form.

16. The method of claim 15 wherein the step of adjusting the level of EGR admitted into the combustion chamber further includes adjusting the level of EGR admitted into the combustion chamber to a highest level such that the average real time ion current signal is at a minimum level where misfire does not occur.

17. The method of claim 16 wherein the step of adjusting the level of EGR to the highest level such that the average real time ion current signal is at the minimum level where misfire does not occur comprises the steps of:

increasing the level of EGR until an individual cycle ionization signal curve has an area at or below a threshold level;

defining a target level for the running average at the point that is one cycle before the individual cycle ionization signal curve with an area at or below the threshold level; and

lowering the level of EGR to the a level such that the average ionization curve for that engine condition stays proximate to the target level.

18. The method of claim 15 further comprising the steps of:

lowering the target average ion current to increase the desired level of EGR; and

raising the target average ion current to decrease the desired level of EGR.

19. The method of claim 15 further comprising the step of determining a starting point of the average ionization current corresponding to the desired level of EGR and wherein the step of comparing an average ion current signal to the target average ion current comprises the step of comparing a starting point of the average ionization current to a desired starting point of the average ionization current.

20. The method of claim 14 further comprising the step of measuring the ionization signal with a negative polarity of ionization on the electrode of an ion sensor.

21. The method of claim 14 further comprising the steps of:

receiving a plurality of ion current signals over a plurality of engine combustion cycles; and

averaging the plurality of ion current signals to derive the real time average ion current.

22. The method of claim 21 wherein the step of receiving the plurality of ion current signals over a plurality of engine combustion cycles comprises the step of measuring the plurality of ion current signals over a set number of engine combustion cycles.

23. The method of claim 14 wherein the step of evaluating the ion current signal comprises the step of evaluating the ion current signal using a spark plug type of ion sensor.

24. The method of claim 14 wherein the step of evaluating the ion current signal comprises the step of evaluating the ion current signal using an ion sensing apparatus integral with an ignition system.

25. A method for controlling the level of exhaust gas recirculation (EGR) admitted into a combustion chamber of a reciprocating HCCI engine comprising the steps of:

evaluating an ionization signal;

adjusting the level of EGR admitted into the combustion chamber based on the evaluation of the ionization signal.

26. The method of claim 25.wherein the step of adjusting the level of EGR admitted into the combustion chamber comprises the steps of:

comparing a real time average ion current signal to a target ion current wave form corresponding to a desired level of EGR; and

adjusting the level of EGR admitted into the combustion chamber such that the real time average ion current signal is within a tolerance window of the target ion current wave form.

27. The method of claim 26 wherein the step of adjusting the level of EGR admitted into the combustion chamber further includes adjusting the level of EGR admitted into the combustion chamber to a highest level such that the average real time ion current signal is at a minimum level where misfire does not occur.

28. The method of claim 27 wherein the step of adjusting the level of EGR to the highest level such that the average real time ion current signal is at the minimum level where misfire does not occur comprises the steps of:

increasing the level of EGR until an individual cycle ionization signal curve has an area at or below a threshold level;

defining a target level for the running average at the point that is one cycle before the individual cycle ionization signal curve with an area at or below the threshold level; and

lowering the level of EGR to the a level such that the average ionization curve for that engine condition stays proximate to the target level.

29. The method of claim 26 further comprising the steps of:

lowering the target average ion current to increase the desired level of EGR; and

raising the target average ion current to decrease the desired level of EGR.

30. The method of claim 29 further comprising the step of determining a starting point of the average ionization current corresponding to the desired level of EGR and wherein the step of comparing an average ion current signal to the target average ion current

comprises the step of comparing a starting point of the average ionization current to a desired starting point of the average ionization current.

31. The method of claim 26 further comprising the steps of:

receiving a plurality of ion current signals over a plurality of engine combustion cycles; and

averaging the plurality of ion current signals to derive the real time average ion current.

32. The method of claim 31 wherein the step of receiving the plurality of ion current signals over a plurality of engine combustion cycles comprises the step of measuring the plurality of ion current signals over a set number of engine combustion cycles.

33. The method of claim 32 wherein the step of measuring the plurality of ion current signals comprises the step of measuring the plurality of ion current signals using a spark plug type of ion sensor.

34. The method of claim 32 wherein the step of measuring the plurality of ion current signals comprises the step of measuring the plurality of ion current signals using an ion sensing apparatus integral with an ignition system.

35. The method of claim 25 further comprising the step of measuring the ionization current with a negative polarity of ionization on the electrode of an ion sensor.

36. An ion sensing apparatus for detecting ion current in a combustion chamber of a diesel engine comprising a spark plug for sensing ion current.

37. The ion sensing apparatus of claim 36 further comprising an ignition driver module for providing energy to the spark plug.

38. The ion sensing apparatus of claim 36 further comprising a control module, the control module including an ionization module for detecting and analyzing the ion current.

39. The ion sensing apparatus of claim 38 wherein the control module further includes a plasma driver for providing high energy sparks to the spark plug.

40. A method to cold start a reciprocating diesel engine in accordance with the spark plug of claim 36 comprising the step of providing sparks to the spark plug located in a combustion chamber of the reciprocating diesel engine wherein the energy of the sparks are of a sufficient magnitude to be able to ignite the diesel fuel mixture in the combustion chamber.

41. The method of claim 40 wherein the step of providing the sparks to the spark plug comprises providing high current sparks of a magnitude that keeps carbon build-up off the ceramic surfaces of the spark plug.

42. A method of preventing misfires in a diesel engine having at least one spark plug comprising the step of providing at least one spark to the at least one spark plug when combustion of the diesel fuel mixture has not begun on time.

43. The method of claim 42 wherein each of the at least one spark plug is located in a cylinder of the diesel engine and wherein the step of providing at least one spark to the at least one spark plug when combustion of the diesel fuel mixture has not begun on time comprises the step of providing at least one spark to the at least one spark plug if combustion has not been sensed prior to a specified crank angle for that cylinder.

44. The method of claim 42 wherein the step of providing at least one spark to the at least one spark plug when combustion of the diesel fuel mixture has not begun on time comprises providing at least one high energy spark after a target crank shaft angle of the rise of ion current has passed corresponding to the latest desired start of combustion.

45. The method of claim 42 further comprising the step of measuring the ion current with a negative polarity of ionization on the electrode of an ion sensor.

46. A method of controlling the start of injection in a direct injection reciprocating compression ignition engine using a spark plug type ion sensor comprising the steps of:

comparing the measured crank shaft angle of the rise of ion current to a target crank shaft angle of the rise of ion current corresponding to a desired start of combustion; and

adjusting the injection timing such that the crank shaft angle of the rise of ion current is within a tolerance window of the target crank shaft angle.

47. The method of claim 46 further comprising the steps of:

retarding a start of injection angle to move an early angle of the rise of ion current towards the given target for the next cycle; and

advancing the start of injection angle to move a late angle of the rise of ion current towards the given target for the next cycle.

48. The method of claim 46 further comprising the step of using an average of at least two prior cycles to determine an average of the rise of ion current.

49. The method of claim 46 further comprising the step of measuring the ion current with a negative polarity of ionization on the electrode of an ion sensor.

50. A method for determining the crank shaft angle at the rise of the ion current signal using a spark plug type of ion current sensor in a combustion chamber of a reciprocating compression ignition engine comprising the steps of:

determining when the ion current signal rises; and

determining the engine crank shaft angle when the ion current signal rises.

51. The method of claim 50 wherein the step of determining the crank shaft angle at the rise of the ion current comprises the steps of:

receiving an ion current signal from the spark plug type of ion current sensor;

determining a change in ion current level before combustion corresponding to a start of the chemical activity of combustion; and

determining the crank shaft angle at the angle where the ion current signal starts to rise.

52. The method of claim 51 wherein the step of receiving the ion current signal from the one of the spark plug type ion sensors comes through an ignition coil.

53. The method of claim 50 further comprising the step of measuring the ion current with a negative polarity of ionization on the electrode of the spark plug type of ion current sensor.

54. A method for controlling the maximum power of a reciprocating engine having at least one combustion chamber comprising the steps of:

determining a target ion current corresponding to a desired burn rate;

comparing an average ion current signal to the target ion current; and

adjusting the amount of fuel admitted into the at least one combustion chamber until the average ion current signal is within a tolerance window of the target ion current.

55. The method of claim 54 further comprising the step of adjusting a timing of the injection of fuel admitted into the at least one combustion chamber.

56. The method of claim 54 further comprising the step of adjusting a rate of the injection of fuel admitted into the at least one combustion chamber.

57 The method of claim 54 further comprising the step of measuring the ionization current with a negative polarity of ionization on the electrode of an ion sensor.

58. A method for controlling the level of exhaust gas recirculation (EGR) admitted into a combustion chamber of a reciprocating engine comprising the steps of:

comparing the real time average peak location of the ion current signal to a target angular peak location of an average ion current corresponding to a desired level of EGR; and

adjusting the level of EGR admitted into the combustion chamber such that the average peak location of the ion current signal is within a tolerance window of the target angular peak location.

59. The method of claim 58 further comprising the step of measuring the ionization current with a negative polarity of ionization on the electrode of an ion sensor.

60. A method for controlling the level of exhaust gas recirculation (EGR) admitted into a combustion chamber of a reciprocating engine comprising the steps of:

comparing a real time delta between the start of combustion and the average peak location of the ion current signal to a target angular delta between the start of combustion and the peak location of the average ion current that corresponds to a desired level of EGR; and

adjusting the level of EGR admitted into the combustion chamber such that the delta between the start of combustion and the average peak location of the ion current signal is within a tolerance window of the target angular delta.

61. The method of claim 60 further comprising the step of measuring the ionization current with a negative polarity of ionization on the electrode of an ion sensor.

62. A method for adjusting the rate of injection of exhaust gas recirculation (EGR) admitted into a combustion chamber of a reciprocating engine comprising the steps of:

comparing a real time delta between the start of combustion and the average peak location of the ion current signal to a target angular delta between the start of combustion and the peak location of the average ion current that corresponds to a desired level of EGR; and

adjusting the rate of injection of EGR admitted into the combustion chamber such that the delta between the start of combustion and the average peak location of the ion current signal is within a tolerance window of the target angular delta.

63. The method of claim 62 further comprising the step of measuring the ionization current with a negative polarity of ionization on the electrode of an ion sensor.

64. A method for controlling the level of exhaust gas recirculation (EGR) admitted into a combustion chamber having two exhaust valves of a reciprocating engine comprising the steps of:

actuating a first exhaust valve of the two exhaust valves in a normal fashion; and

variably actuating a second exhaust valve of the two exhaust valves corresponding to a desired level of EGR.

65. The method of claim 64 wherein the step of variably actuating the second exhaust valve includes the step of opening the second exhaust valve for varying lengths of time during an intake stroke of the reciprocating engine.

66. The method of claim 65 wherein the step of opening the second exhaust valve for varying lengths of time during an intake stroke includes the step of opening the second exhaust valve for varying lengths of time based upon feedback from an ionization current signal in order to achieve the desired level of the level of EGR admitted into the combustion chamber.

67. The method of claim 66 further comprising the step of measuring the ionization current with a negative polarity of ionization on the electrode of an ion sensor.

68. A method for controlling the start of combustion of a dual mode reciprocating engine having a combustion chamber in which combustion is normally spark ignited comprising the step of controlling the level of exhaust gas recirculation (EGR)

admitted into the combustion chamber based upon ionization current feedback after sparks are turned off.

69. The method of claim 68 wherein the method of controlling the start of combustion further comprises the steps of:

comparing the measured crank shaft angle of the rise of ion current to a target crank shaft angle of the rise of ion current corresponding to a desired start of combustion; and

adjusting the level of EGR admitted into the combustion chamber such that the crank shaft angle of the rise of ion current is within a tolerance window of the target crank shaft angle.

70. The method of claim 69 further comprising the step of adjusting a temperature of the EGR admitted into the combustion chamber to an optimum temperature for combustion.

71. The method of claim 69 wherein the step adjusting the level of EGR admitted into the combustion chamber comprises the steps of:

decreasing the level of EGR admitted into the combustion chamber to move an early angle of the rise of ion current towards the given target for the next cycle; and

increasing the level of EGR admitted into the combustion chamber to move a late angle of the rise of ion current towards the given target for the next cycle.

72. The method of claim 69 wherein the step of comparing the measured crank shaft angle of the rise of ion current uses an average of at least two prior cycles to determine the average of the rise of ion current.

73. The method of claim 68 further comprising the step of measuring the ionization current with a negative polarity of ionization on the electrode of an ion sensor.

74. A method of controlling the burn rate in a diesel engine having a combustion chamber using a target angle of the second peak of an ion current waveform corresponding to a desired burn rate, the method comprising the steps of:

comparing a real time average of the crank shaft angle of the second peak of the ion current wave form to the target angle; and

adjusting the rate of fuel admitted into the combustion chamber such that the real time average of the angle of the second peak of the ion current waveform is within a tolerance window of the target angle.

75. The method of claim 74 wherein the step of adjusting the rate of fuel admitted into the combustion chamber comprises the steps of:

if the real time average of the crank shaft angle of the second peak of the ion current wave form is advanced of the target angle, decreasing the rate of fuel admitted into the combustion chamber until the real time average of the crank shaft angle of the second peak of the ion current wave form is within a tolerance of the target angle; and

if the real time average of the crank shaft angle of the second peak of the ion current wave form is retarded of the target angle, increasing the rate of fuel admitted into the combustion chamber until the real time average of the crank shaft angle of the second peak of the ion current wave form is within a tolerance of the target angle.

76. The method of claim 74 wherein the start of injection in a diesel engine is also controlled by the ion current wave form, the method further comprising the steps of:

comparing the measured crank shaft angle of the rise of ion current to the target crank shaft angle corresponding to a desired start of combustion; and

adjusting the injection timing such that the crank shaft angle of the rise of ion current is within a tolerance window of the target crank shaft angle.

77. The method of claim 76 wherein the step of adjusting the injection timing comprises the steps of:

retarding a start of injection angle to move an early angle of the rise of ion current towards the target crank shaft angle for the next cycle; and

advancing the start of injection angle to move a late angle of the rise of ion current towards the given target crank shaft angle for the next cycle.

78. A method for controlling the maximum power of a diesel engine having a combustion chamber comprising the steps of:

determining a target ion current waveform corresponding to a maximum burn rate;

comparing a real time average ion current waveform to the target ion current waveform; and

increasing at least one of a rate of fuel admitted into the combustion chamber and an amount of fuel admitted into the combustion chamber until the average ion current waveform is within a tolerance window of the target ion current waveform.

79. A method of controlling the maximum power of a diesel engine by maximizing the second peak of the ion current waveform at a target angle corresponding to a desired burn rate, the method comprising the steps of:

comparing a real time average of an amplitude and crank shaft angle of the second peak of the ion current waveform to the target angle; and

adjusting one of a rate of fuel admitted into the combustion chamber and an amount of fuel admitted into the combustion chamber such that the real time average of the angle of the second peak of the ion current waveform is maximized within a tolerance window of the target angle.

80. The method of claim 79 wherein the steps of controlling the maximum power to the ideal level such that the second peak of the average real time ion current signal is maximized at the target angle, comprising the steps of:

if the real time average of the crank shaft angle of the second peak of the ion current wave form is advanced of the target angle, decreasing the one of the rate of fuel admitted into the combustion chamber and the amount of fuel admitted into the combustion chamber until the real time average of the crank shaft angle of the second peak of the ion current wave form is within a tolerance of the target angle; and

if the real time average of the crank shaft angle of the second peak of the ion current wave form is retarded of the target angle, increasing one of the rate of fuel admitted into the combustion chamber and the amount of fuel admitted into the combustion chamber until the real time average of the crank shaft angle of the second peak of the ion current wave form is within a tolerance of the target angle.

81. The method of claim 79 wherein the start of injection in a diesel engine is also controlled using the ion current waveform, the method further comprising the steps of:

comparing the measured crank shaft angle of the rise of ion current to a target crank shaft angle of the rise of ion current corresponding to a desired start of combustion; and

adjusting the injection timing such that the crank shaft angle of the rise of ion current is within a tolerance window of the target crank shaft angle.

82. The method of claim 81 wherein the step of adjusting the injection timing comprises the steps of:

retarding a start of injection angle to move an early angle of the rise of ion current towards the target crank shaft angle for the next cycle; and

advancing the start of injection angle to move a late angle of the rise of ion current towards the target crank shaft angle for the next cycle.

83. A method for controlling the maximum power of a directly injected reciprocating engine comprising the steps of:

determining target average ion current features corresponding to the fastest allowable burn rate;

comparing a real time average ion current signal features to the target average ion current features; and

adjusting one of the rate of fuel admitted into the combustion chamber and the amount of fuel admitted into the combustion chamber such that the real time average ion current signal features are within a tolerance window of the target average ion current features.

84. The method of claim 83 wherein the step of adjusting the one of the rate of fuel admitted into the combustion chamber and the amount of fuel admitted into the combustion chamber includes the step of adjusting the timing of fuel admitted into the combustion chamber.

85. An apparatus that measures ionization in a direct injected engine having an injector, the apparatus comprising the injector adapted to sense ions, wherein the injector is insulated from ground and pulled to a negative voltage for ion sensing.

86. The apparatus of claim 85 further comprising a drive circuit for the injector that is isolated from the negative voltage.

87. The apparatus of claim 85 further comprising a drive circuit having a diode electrically connected to ground so as to flow positive voltage while holding back the negative voltage.